Section 8.0 METHODOLOGY USED TO MODEL INSPECTION AND MAINTENANCE (I&M) PROGRAMS

This section describes how inspection and maintenance (I&M) or smog check programs effect basic exhaust emission rates, and how these effects were simulated in the CALIMFAC[1] (preprocessor to the MVEI7G model) and EMFAC2000 models.

8.1 Introduction

The basic exhaust and evaporative emission rates increase as a function of vehicle age and/or mileage. This deterioration in emissions control occurs as a result of vehicle defects and/or malmaintenance, which includes tampering by the vehicle owner. Historically, two strategies have been employed to reduce emissions from motor vehicles; the first approach relied on lowering the emission standards from new vehicles, the second was to lower emissions from in-use vehicles. The primary goal of an I&M program is to reduce emissions from in-use vehicles by identifying and repairing malperforming vehicles during periodic inspections. In California, the first statewide biennial inspection program was introduced in 1984. In this program raw exhaust concentrations of hydrocarbon and carbon monoxide emissions were measured at idle from gasoline fueled passenger cars (PC), light-duty trucks (LDT) and medium trucks (MDV). These raw measurements were then compared to emission cutpoints to determine the pass/fail status of the vehicle. In addition, the mechanic would perform a visual and functional check of the air injection system, exhaust gas re-circulation system, oxygen sensor and the catalyst. The vehicle owner was required to spend up to $50 for repair if the vehicle failed either the exhaust or the visual/functional test. The owner was issued a repair waiver if the total cost of repairs exceeded $50. The 1984 program was first revised by the State legislature in 1990 (1990 I&M) and then again in 1996 (enhanced program) with the goal of improving the identification and repair rates. As a result, some vehicles have been subject to three different I&M programs in their lifetime. For example, a 1980 model year vehicle has been subject to the 1984, 1990 and enhanced I&M programs. Table 8-1 provides detail on the type of inspections, repair cost limits, and visual/functional checks performed in each program.

Figure 8-1 shows a comparison of how emissions from vehicles increase, with the same model year and technology that undergo a biennial inspection versus those that bypass the inspection program. The first inspection is represented by point A in figure 8-1. The change in emissions from point A to point B reflects the fact that some vehicles are identified and repaired at smog check. The emissions then increase due to vehicle deterioration, and are reduced again at the next inspection. The mid-point of the saw tooth represents the average emissions increase for vehicles subject to an I&M program. In Figure 8-1 further changes to the I&M program, i.e. changing to ASM testing are reflected by points C and D. Figure 8-1 illustrates three key components necessary for modeling an I&M program. These are:

[1] CALIMFAC: California's I&M Benefits Model, developed in June 1990 by Sierra Research under contract to the Air Resources Board.

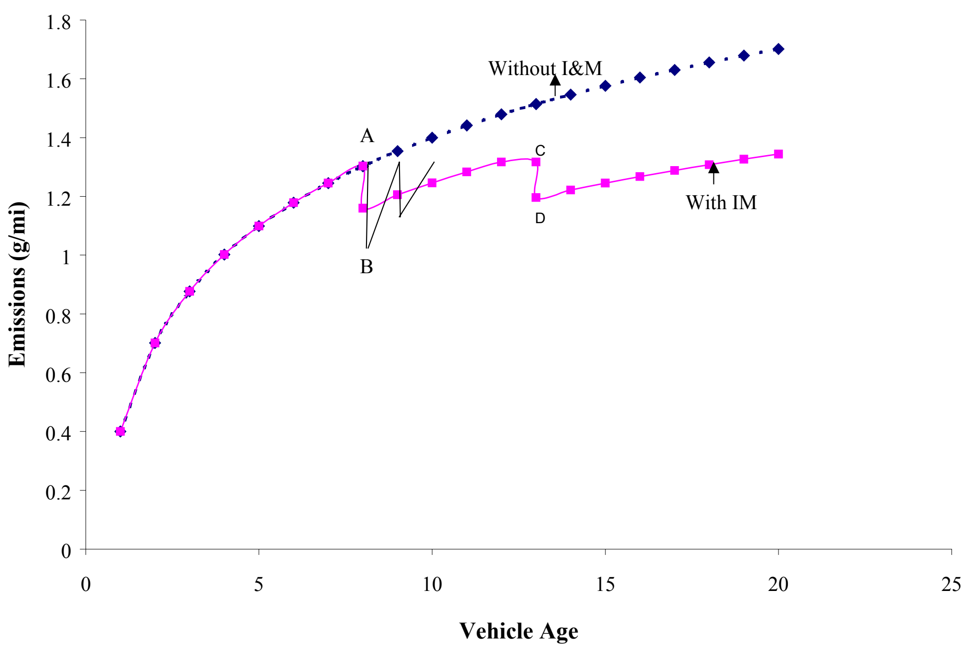
Table 8-1 California's Inspection and Maintenance Programs

I&M Program	Start date	Vehicle Type	Model Year Group	Test Type	Emissions Measured	Repair Cost Limit ($)	Type of Visual & Funcational	Evap. System Check	New Vehicle Exemptions
1984 or	March, 1984	PC-MDV	1965-79	Idle Only	HC, CO	50	Air/EGR/O2-sensor/Cat	None	1 Year
BAR 84		PC-MDV	1980+	Idle+2500		50	Air/EGR/O2-sensor/Cat	None	1 Year
1990 or	July, 1990	PC-MDV	Pre-1972	Idle+2500	HC, CO	50	Full Visual & Functional	None	1 Year
BAR 90		HDV	1972-74	Idle+2500		90	Full Visual & Functional	None	1 Year
			1975-79	Idle+2500		125	Full Visual & Functional	None	1 Year
			1980-89	Idle+2500		175	Full Visual & Functional	None	1 Year
			1990+	Idle+2500		300	Full Visual & Functional	None	1 Year
Enhanced Basic	August, 1997	PC-MDV + HDV	1974+	Idle+2500	HC, CO,	450	Full Visual & Functional	Gas Cap	4 Years
Enhanced	June, 1998(*)	PC-MDV	1974+	ASM	HC, CO, NOx	450	Full Visual & Functional	Gas Cap	4 Years

(*) Although ASM testing began in June, 1998 it is assumed that the required cutpoints will not be in place until sometime in 2001.

Figure 8-1 Illustration of How I&M Programs Lower Vehicle Deterioration Rates

1. Identification Rate: This is the number of vehicles at point A that fail the inspection

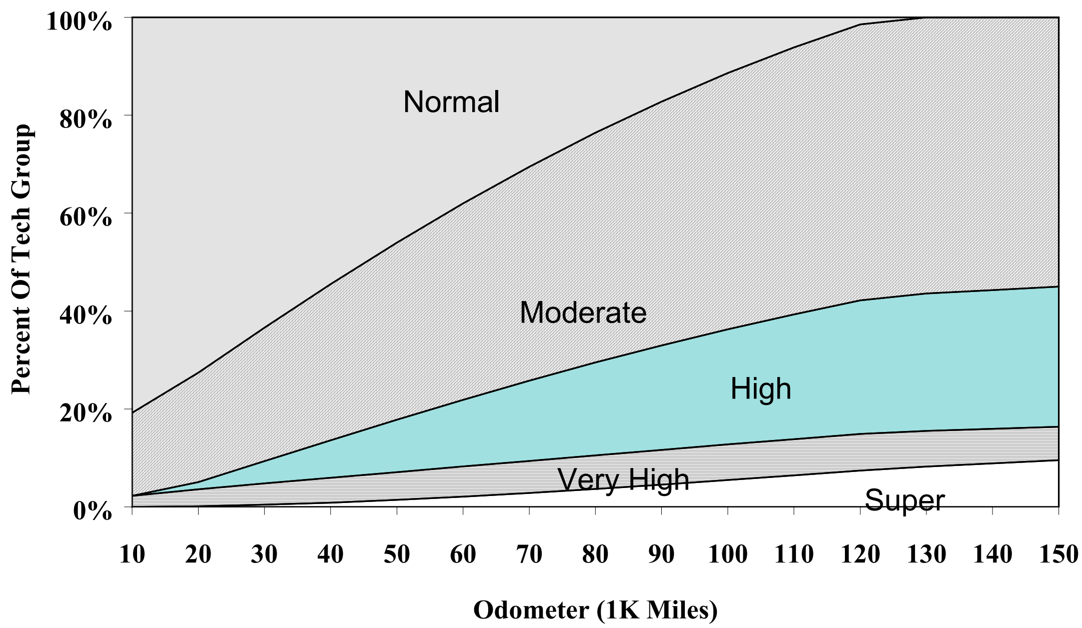


   program.
2. Repair Effectiveness: This is a measure of how well the failing vehicles are repaired as indicated by the reduction in emissions from points A to B.
3. Vehicle Deterioration: What is the deterioration rate for vehicles that have undergone an I&M program.

8.2 Background

This section describes how I&M programs were simulated in the CALIMFAC model, and how they are modeled in EMFAC2000. Following is a sample calculation of how one I&M cycle is simulated. This illustrates some of the similarities and differences in how I&M is modeled in both models. Both models start by calculating the populations of each regime as a function of vehicle mileage. Figure 8-2 shows an example of the regime sizes for Oxides of Nitrogen (NOx) for vehicles in technology group 12.

Figure 8-2 <u>Regime Sizes for Vehicles in Technology Group 12</u>



Assuming that the first inspection occurs at 100,000 miles, the model calculates that 5.5%, 7.3%, 23.5%, 52.3% and 11.4% of the vehicles in technology group 12 are supers, very highs, highs, moderates and normal[1] emitters for NOx, respectively. This regime specific population distribution is then multiplied by the regime specific identification rates (Table 8-1) to calculate the number of passing and failing vehicles. The identification rate is the percentage of vehicles, by regime, that will fail a given I&M program. The failing vehicles are repaired as indicated by the movement towards lower emitting regimes. For example, of the 4.5 supers that were repaired; 1.3 remained as supers, 2.6 became very high emitters and 0.6 became high emitters. This distribution of vehicles after repair is known as the "post-repair move matrix." The distribution of vehicles after repair is then added to the distribution of passing vehicles to calculate the "post-repair matrix." After one I&M cycle 2.8%, 10.3%, 22.8%, 51.5% and 12.6% of the vehicles in technology group 12 are super, very high, high, moderate and normal

[1] Section 4.5 details how vehicles within a particular technology group are classified into the normal, moderate, high, very high and super emission regimes.

emitters, respectively. The after-repair regime specific populations then grow (or deteriorate) according to the after-repair regime growth rates.

Table 8-1 Example of One I&M Cycle

					Post Repair Move Matrix						Post Repr
	100K	ID_rate	Passed	Failed	N	M	H	VH	S		+Passing
S	5.5	0.82	1.0	4.5	0.0	0.0	0.6	2.6	1.3		2.8
V	7.3	0.66	2.5	4.8	0.1	0.2	1.0	3.2	0.3		10.3
H	23.5	0.69	7.3	16.2	0.6	1.2	12.1	2.1	0.2		22.8
M	52.3	0.39	31.9	20.4	0.9	17.7	1.8	0.0	0.0		51.5
N	11.4	0.3	8.0	3.4	2.9	0.5	0.0	0.0	0.0		12.6
				Total	4.6	19.6	15.5	7.9	1.8		100.0

S=*Super* V=*Very High*, H=*High*, M=*Moderate*, N=*Normal*

The example described above shows in general terms how an I&M cycle is simulated in both the CALIMFAC and EMFAC2000 models. The following sections provide more detail on the data sources, identification rates, repair move matrices and how deterioration is modeled in both models.

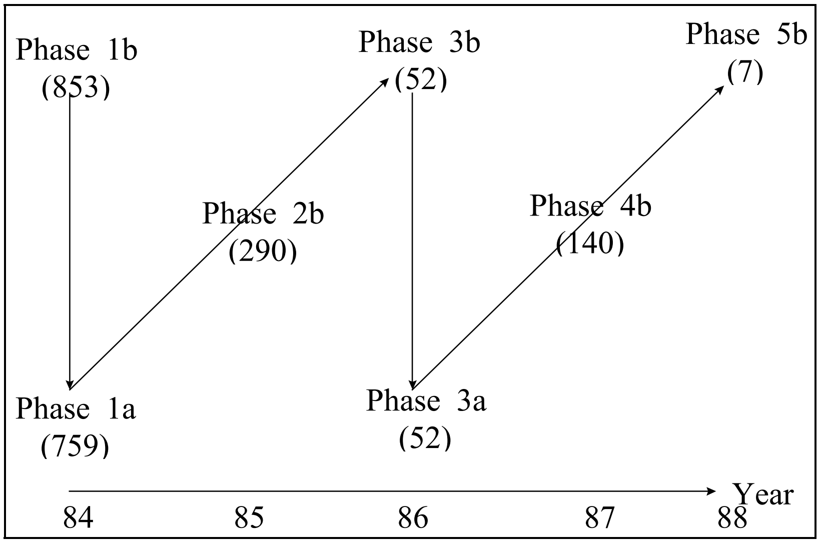
8.3 Data Sources

1984 I&M Program

The 1984 I&M evaluation program consisted of five phases carried out over a period of five years, beginning in 1984. Figure 8-3 shows the number of vehicles tested during each phase. The same group of vehicles was tested during phase_1b, phase_1a, phase_2b and phase_4b. Another group of vehicles, mainly 1980 and newer, was tested during other phases of the program.

During phase_1b, 853 vehicles failing the BAR 84 test were procured and given a baseline FTP and a BAR 84 test at CARB's Haagen-Smit Laboratory (HSL). These vehicles were then sent randomly to smog check stations in the South Coast Air Basin (SCAB). Repairs performed at these stations were noted in a database. These vehicles were then given a confirmatory BAR 84 test and an after-repair FTP test at HSL. In the second phase, vehicles were brought in and given a baseline FTP and a BAR 84 test. In phase_3, another group of vehicles was procured and subjected to the same sequence of tests as vehicles in phase_1. A subset of vehicles tested in phase_1 were procured for baseline FTP tests during phase_4. During phase_5, a subset of vehicles tested in phase_3 were procured and given a baseline FTP test.

Figure 8-3 **Vehicles Tested During The 1984 I&M Evaluation Program**



Where:
The letters “b” and “a” refer to baseline and after-repair tests.

The 1984 I&M evaluation program data was used to:

1. Calculate identification rates for vehicles tested in phase_1b.
2. Calculate repair move matrices for vehicles tested in phase_1 and phase_3.
3. Calculate move matrices that describe the movement of vehicles between inspection cycles.
4. Calculate deterioration rates for vehicles tested in phase_2 and phase_4, and compare them to each other, to vehicles tested in the 1990 I&M program, and to vehicles not subject to an I&M program.

1990 I&M Program

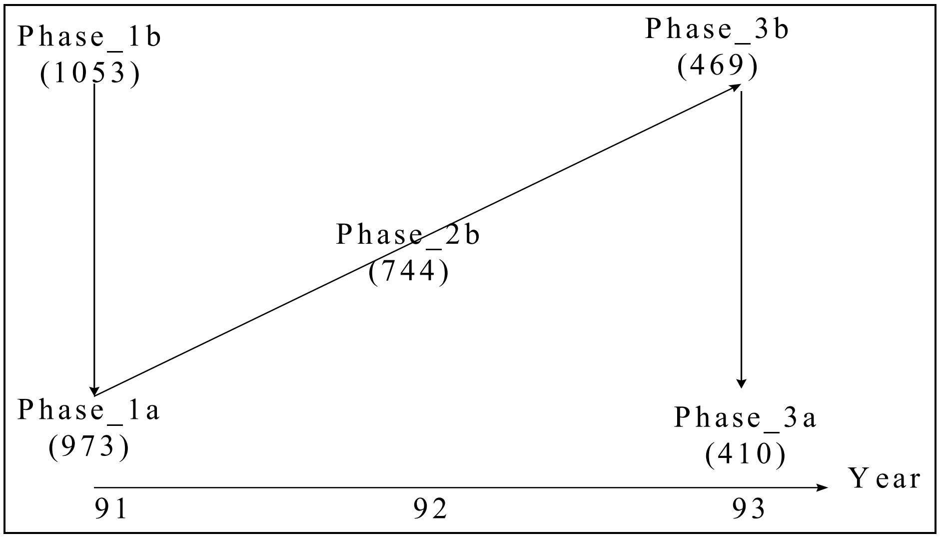
The 1990 I&M evaluation program consisted of three phases (Figure 8-4) carried out over a period of three years beginning in 1991. Figure 8-4 shows the number of vehicles tested during each phase. The same group of vehicles was tested during the various phases.

Vehicles in the 1990 I&M evaluation program were subject to the same testing sequences as vehicles in the 1984 I&M evaluation program, with the exception that they were tested using the BAR 90 inspection test. The data from the 1990 I&M evaluation program was used to:

1. Calculate identification rates for vehicles tested in phase_1b.
2. Calculate repair move matrices for vehicles tested in phase_1 and phase_3.

3. Calculate move matrices that describe the movement of vehicles between inspection cycles.
4. Calculate deterioration rates for vehicles tested in phase_2 to vehicles tested in the 1984 I&M program, and for vehicles not subject to an I&M program.

Figure 8-4 <u>Vehicles Tested During The 1990 I&M Evaluation Program</u>



Where:
The letters "b" and "a" refer to baseline and after-repair tests.

<u>1998 I&M Program</u>

CARB's 1994 Pilot program data was analyzed to calculate repair move matrices for vehicles subject to a $450-500 repair cost limit. In the Pilot program, 199 vehicles were sent for repair to an off-site repair facility. Of these, 34 vehicles were removed because they "ping-ponged" between CARB's HSL and the repair facility. Staff believe that with proper preconditioning, which is allowed in the enhanced I&M program, these vehicles would have passed the initial screening test. Further, these vehicles did not receive any repairs because they passed at the repair facility. Five vehicles that did not receive repairs due to cost limitations were kept in the data set.

Staff believe that this 165 vehicle data set is insufficient to adequately populate the model year group specific repair move matrices. For this reason, data from the light-duty vehicle surveillance 13 program were also used in calculating the move matrices. Vehicles in this program were also subject to the $450-500 repair cost limit and were tested using the same ASM cutpoints. Combined, the data set contained 323 vehicles.

<u>Without I&M Data</u>

The without I&M data set contains data from CARB's light-duty surveillance programs 1 through 9. This data was used to generate the "master data set" for use in the CALIMFAC model. In addition, this data set was supplemented with U. S. EPA's without I&M data. Combined, test data from 3,361 vehicles were used in calculating the deterioration rates for vehicles not subject to an I&M program.

8.4 Identification Rates

The identification rates (ID) represent the percent of vehicles in a given technology group and emissions regime that fail an I&M program with particular cutpoints, visual and functional checks, and mechanic performance.

In the CALIMFAC model the ID rate was calculated by adding two probabilities. Vehicles failing the exhaust test were assigned a probability of one, whereas, vehicles failing only the visual/functional test were assigned a probability that was dependent on the mechanic's ability to identify malperforming components. It is important to note that the CALIMFAC model was developed in 1990; hence assumptions were made regarding mechanic repair effectiveness and performance especially in modeling the benefits from the 1990 and loaded mode testing programs. In the CALIMFAC model, the ID rates were calculated for two emission stringency levels for three I&M programs (1984, 1990 and loaded mode), and by three levels of visual/functional checks (Table 8-2).

Table 8-2

Program Type	No Visual & Functional Checks	Check AIR, EGR, O2S and CAT	Check AIR, EGR, O2S, CAT, EVAP, Crankcase, Fillpipe
1984	3-Levels of M.P.	3-Levels of M.P.	3-Levels of M.P.
1990	3-Levels of M.P.	3-Levels of M.P.	3-Levels of M.P.
Loaded Mode	3-Levels of M.P.	3-Levels of M.P.	3-Levels of M.P.

Where: M.P. is Mechanic Performance

In addition, the ID rates were also calculated for three levels of mechanic performance (basic, enhanced and best). The basic level corresponds to the mechanic training in the 1984 program. For a given technology group the ID rates for each cell in Table 8-2 were calculated by first determining how many vehicles failed the exhaust test. These vehicles were then assigned a probability of one. The probability that the remaining vehicles would be identified by the visual/functional checks was based on mechanics ability in identifying the malperforming components. These probabilities were calculated based on an analysis of the 1984 I&M evaluation data. Additional assumptions were made to increase these ID rates for improvements in mechanic training. For example, it was assumed that enhanced mechanic performance would increase the identification rates by 50%, up to the level achieved with OBD2 vehicles.

In EMFAC2000, the ID rates are only calculated for three I&M programs (1984, 1990 and enhanced), and are not a function of mechanic performance. In EMFAC2000, the ID rates were simplified because of the availability of test data from the 1990 and enhanced I&M evaluation programs. The ID rates, by model year group and emissions regime, for vehicles failing either the exhaust emissions test only or the visual/functional test only were calculated as:

$$ID_{exhaust} = \frac{\text{Number of vehicles failing the emissions test during smog check}}{\text{Total number of vehicles}}$$

$$ID_{visual/functional} = \frac{\text{Number of vehicles only failing for V/F defects during smog check}}{\text{Total number of vehicles}}$$

In phase_1b of the 1984 I&M program, 853 vehicles failing the BAR 84 test were given a baseline FTP and a BAR 84 test at HSL. These vehicles were then sent for smog checks to randomly selected smog check stations in the SCAB. Vehicles from phase_1b were first classified into the EMFAC2000 emission regimes. The ID rates were then calculated as shown above. The overall ID is the sum of the individual rates. Table 8-3 shows the ID rates for vehicles subject to the 1984 I&M program. The approach described above was also used in calculating the ID rates (Table 8-4) for vehicles subject to the 1990 I&M program. Please note the ID rates from lower emission regimes that have more vehicles were used in instances where the number of vehicles is too small for a valid estimate of the ID rate.

Using data from the 1994 I&M Pilot program staff calculated the ID rates for vehicles subject to the new 1998 enhanced I&M program. The ID rates were calculated for vehicles subject to either CARB's or BAR's ASM standards. These ID rates only represent the probability of identifying a vehicle based solely on it failing the exhaust test. The probability of identifying vehicles that only fail the visual/functional portion of the new enhanced test cannot be assessed from the Pilot program data. It was assumed that the overall ID rate will be the same as the exhaust emissions ID rate since mechanics are more likely to perform the emissions test first, and only check for visual/functional defects once the vehicle has failed the emissions test. This may preclude them from finding vehicles that only fail the visual/functional portion of the test. However, to model the possibility that some vehicles may be identified as only failing the visual/functional portion of the test, staff believe that visual/functional ID rate should be set to zero in the model. This provides an opportunity to change these ID rates when more data becomes available.

The question that remains is, what will the ID rate be for vehicles equipped with an OBDII system (mainly for 1996 and newer model year vehicles)? In the CALIMFAC model, it was assumed that 95 percent of the failures for vehicles in the high to super emission regimes would be identified by the OBD II system. Staff has reviewed some preliminary data collected by CARB's Advanced Engineering section, which indicates that the OBDII system is correctly identifying failures occurring in TLEV vehicles emitting at or below the normal emissions regime. On this basis, staff believes that the interim OBDII identification rates should be set to identify 95 percent of vehicles in the high to super emissions regime. This ID rate will be revised when more data become available. Upon repair these vehicles move evenly to the normal and moderate emission regimes. This assumes an almost perfect repair, and this may be the case since only a proper repair will deactivate the MIL.

8.5 Repair

Once the failing vehicles have been tagged in each emission regime, repair is simulated by moving vehicles from higher to lower emission regimes (see Table 8-1). In the CALIMFAC model the maximum movement of vehicles from before-repair to after-repair is based on an analysis of CARB's in-use vehicle surveillance data. The baseline FTP data and the final (after-extensive ARB repairs) FTP data were used in determining the number of vehicles in each regime at baseline and after perfect repairs. This information was used in constructing the pre-repair and post repairs move matrices. The difference between these two regime distributions represented the maximum movement of vehicles when there are no repair cost limits and assumed perfect repairs. Mitigating the maximum movement of these vehicles via correction efficiencies (Table 8-5) then simulated the repairs performed at smog check stations. The correction efficiencies varied according to the I&M program being simulated and were a function of the repair cost limits and the level of mechanic repair effectiveness. The correction efficiencies for the 1984 Level (option 1) were based on data from the 1984 I&M evaluation program. For the same option, the correction efficiencies for enhanced mechanic training were determined by examining vehicle diagnostic information and deciding if additional repairs could have been done under the $50 repair cost limit with additional mechanic training. The remaining correction efficiencies were estimated either by interpolation or by assessing the cost of additional repairs.

Table 8-5 Correction Efficiencies Used In The CALIMFAC Model

	Model Year Group	Cost Limit ($)	1984 Level	1990 Level	Enhanced Training
Option 1	Pre-1975	50	0.69*	0.79	0.89**
1984 I&M	1975-79	50	0.64*	0.72	0.80**
	1980+	50	0.46*	0.56	0.66**
Option 2	Pre-1972	50	0.69	0.79	0.89
1990 I&M	1972-74	90	0.73	0.83	0.94
	1975-79	125	0.70	0.79	0.88
	1980-89	175	0.59	0.72	0.84
	1990+	300	0.64	0.78	0.92
Option 3	Pre-1975	no limit	0.78	0.89	1.00
	1975-79	no limit	0.80	0.90	1.00
	1980+	no limit	0.70	0.85	1.00

* Determined from 1984 I&M Evaluation Program

** Determined from 1984 I&M Evaluation Program by examining ARB diagnostic information and deciding what could have been repaired under the $50 cost limit.

Table 8-3 <u>Identification Rates For Vehicles Subject To The 1984 I&M Program</u>

	Pre-1975 Vehicles				1975-79 Model Year Vehicles				1980 and Newer Vehicles				All Vehicles			
HC	Regime	Emissions	Vis/Func	Overall	Regime	Emissions	Vis/Func	Overall	Regime	Emissions	Vis/Func	Overall	Regime	Emissions	Vis/Func	Overall
pre-1975	Totals	Idrate	Idrate	Idrate	Totals	Idrate	Idrate	Idrate	Totals	Idrate	Idrate	Idrate	Totals	Idrate	Idrate	Idrate
Norm																
	69	0.2029	0.3478	0.5507	22	0.0455	0.2273	0.2727	28	0.1786	0.2500	0.4286	119	0.1681	0.3025	0.4706
Modr																
	79	0.5190	0.1266	0.6456	77	0.1558	0.2338	0.3896	83	0.3735	0.1084	0.4819	239	0.3515	0.1548	0.5063
High																
	21	0.7143	0.0952	0.8095	143	0.4965	0.1538	0.6503	63	0.5238	0.0952	0.6190	227	0.5242	0.1322	0.6564
V_High		***0.7143***	***0.0952***	***0.8095***												
	6	0.8333	0.0000	0.8333	37	0.7568	0.0541	0.8108	22	0.9091	0.0455	0.9545	65	0.8154	0.0462	0.8615
Supr																
	11	0.8182	0.0909	0.9091	18	0.7778	0.1111	0.8889	10	0.9000	0.1000	1.0000	39	0.8205	0.1026	0.9231
CO	Regime	Emissions	Vis/Func	Overall	Regime	Emissions	Vis/Func	Overall	Regime	Emissions	Vis/Func	Overall	Regime	Emissions	Vis/Func	Overall
pre-1975	Totals	Idrate	Idrate	Idrate	Totals	Idrate	Idrate	Idrate	Totals	Idrate	Idrate	Idrate	Totals	Idrate	Idrate	Idrate
Norm																
	75	0.3733	0.2267	0.6000	64	0.1406	0.2031	0.3438	63	0.2540	0.1587	0.4127	202	0.2624	0.1980	0.4604
Modr																
	68	0.4412	0.2353	0.6765	98	0.2857	0.2143	0.5000	66	0.4848	0.0909	0.5758	232	0.3879	0.1853	0.5733
High																
	30	0.6000	0.0667	0.6667	70	0.5429	0.1571	0.7000	48	0.5208	0.1042	0.6250	148	0.5473	0.1216	0.6689
V_High																
	10	0.7000	0.2000	0.9000	36	0.7222	0.0556	0.7778	12	0.8333	0.0833	0.9167	58	0.7414	0.0862	0.8276
Supr		***0.7000***	***0.2000***	***0.9000***												
	3	0.3333	0.0000	0.3333	30	0.8333	0.0667	0.9000	16	0.8750	0.1250	1.0000	49	0.8163	0.0816	0.8980
NOx	Regime	Emissions	Vis/Func	Overall	Regime	Emissions	Vis/Func	Overall	Regime	Emissions	Vis/Func	Overall	Regime	Emissions	Vis/Func	Overall
pre-1975	Totals	Idrate	Idrate	Idrate	Totals	Idrate	Idrate	Idrate	Totals	Idrate	Idrate	Idrate	Totals	Idrate	Idrate	Idrate
Norm																
	99	0.4848	0.1717	0.6566	76	0.5132	0.1711	0.6842	75	0.5600	0.1067	0.6667	250	0.5160	0.1520	0.6680
Modr																
	45	0.5111	0.1778	0.6889	76	0.4079	0.1184	0.5263	72	0.4444	0.1250	0.5694	193	0.4456	0.1347	0.5803
High																
	28	0.2857	0.3571	0.6429	109	0.3670	0.2202	0.5872	36	0.5278	0.0833	0.6111	173	0.3873	0.2139	0.6012
V_High		***0.2857***	***0.3571***	***0.6429***												
	9	0.5556	0.2222	0.7778	30	0.3667	0.1000	0.4667	18	0.2778	0.1111	0.3889	57	0.3684	0.1228	0.4912
Supr		***0.2857***	***0.3571***	***0.6429***		***0.3667***	***0.1000***	***0.4667***		***0.2778***	***0.1111***	***0.3889***				
	5	0.0000	0.0000	0.0000	7	0.7143	0.0000	0.7143	5	0.0000	0.4000	0.4000	17	0.2941	0.1176	0.4118

Table 8-4 <u>Identification Rates For Vehicles Subject To The 1990 I&M Program</u>

	Pre-1975 Vehicles				1975-79 Model Year Vehicles				1980 and Newer Vehicles				All Vehicles			
	Regime	Emissions	Vis/Func	Overall	Regime	Emissions	Vis/Func	Overall	Regime	Emissions	Vis/Func	Overall	Regime	Emissions	Vis/Func	Overall
pre-1975	Totals	Idrate	Idrate	Idrate	Totals	Idrate	Idrate	Idrate	Totals	Idrate	Idrate	Idrate	Totals	Idrate	Idrate	Idrate
Norm						***0.0645***	***0.3226***	***0.3871***								
	60	0.3833	0.2500	0.6333	6	0.1667	0.0000	0.1667	30	0.1333	0.1667	0.3000	96	0.2917	0.2083	0.5000
Modr																
	67	0.5075	0.1791	0.6866	31	0.0645	0.3226	0.3871	109	0.2110	0.1835	0.3945	207	0.2850	0.2029	0.4879
High																
	21	0.5238	0.0952	0.6190	145	0.3724	0.1793	0.5517	184	0.5598	0.1304	0.6902	350	0.4800	0.1486	0.6286
V_High																
	11	0.7273	0.0000	0.7273	57	0.5263	0.1228	0.6491	130	0.6154	0.0462	0.6615	198	0.5960	0.0657	0.6616
Supr																
	14	0.7143	0.0714	0.7857	40	0.7250	0.0750	0.8000	39	0.7949	0.0256	0.8205	93	0.7527	0.0538	0.8065
	Regime	Emissions	Vis/Func	Overall	Regime	Emissions	Vis/Func	Overall	Regime	Emissions	Vis/Func	Overall	Regime	Emissions	Vis/Func	Overall
pre-1975	Totals	Idrate	Idrate	Idrate	Totals	Idrate	Idrate	Idrate	Totals	Idrate	Idrate	Idrate	Totals	Idrate	Idrate	Idrate
Norm																
	70	0.4286	0.2286	0.6571	40	0.2000	0.2500	0.4500	77	0.2208	0.0909	0.3117	187	0.2941	0.1765	0.4706
Modr																
	70	0.5143	0.1429	0.6571	87	0.2414	0.2644	0.5057	121	0.3967	0.2149	0.6116	278	0.3777	0.2122	0.5899
High																
	21	0.5714	0.1429	0.7143	62	0.4839	0.0968	0.5806	183	0.5519	0.0929	0.6448	266	0.5376	0.0977	0.6353
V_High																
	12	0.6667	0.0000	0.6667	50	0.6200	0.0800	0.7000	57	0.5789	0.0877	0.6667	119	0.6050	0.0756	0.6807
Supr		***0.6667***	***0.0000***	***0.6667***												
	0	0.0000	0.0000	0.0000	40	0.6500	0.0750	0.7250	54	0.7778	0.0185	0.7963	94	0.7234	0.0426	0.7660
	Regime	Emissions	Vis/Func	Overall	Regime	Emissions	Vis/Func	Overall	Regime	Emissions	Vis/Func	Overall	Regime	Emissions	Vis/Func	Overall
pre-1975	Totals	Idrate	Idrate	Idrate	Totals	Idrate	Idrate	Idrate	Totals	Idrate	Idrate	Idrate	Totals	Idrate	Idrate	Idrate
Norm																
	112	0.4911	0.1607	0.6518	79	0.4810	0.1139	0.5949	102	0.5784	0.0490	0.6275	293	0.5188	0.1092	0.6280
Modr																
	46	0.4783	0.1522	0.6304	76	0.4079	0.1711	0.5789	150	0.4800	0.1000	0.5800	272	0.4596	0.1287	0.5882
High		***0.6000***	***0.2667***	***0.8667***												
	8	0.3750	0.5000	0.8750	86	0.3837	0.1512	0.5349	100	0.4100	0.1500	0.5600	194	0.3969	0.1649	0.5619
V_High		***0.6000***	***0.2667***	***0.8667***												
	3	1.0000	0.0000	1.0000	24	0.4167	0.2917	0.7083	82	0.4634	0.1707	0.6341	109	0.4679	0.1927	0.6606
Supr		***0.6000***	***0.2667***	***0.8667***												
	4	0.7500	0.0000	0.7500	14	0.2857	0.2857	0.5714	58	0.5345	0.1207	0.6552	76	0.5000	0.1447	0.6447

Table 8-6 shows the actual correction efficiencies determined from an analysis of the 1990 I&M evaluation program. Comparison of the actual versus projected correction efficiencies (Tables 8-5 & 8-6) from the 1990 I&M program indicate that the projected improvements to the mechanic repair effectiveness level, from higher repair cost limits and enhanced training, were overly optimistic.

Table 8-6 Correction Efficiencies Based On 1990 I&M Program

Model Year Group	Repair Cost Limit ($)	1990 Level
Pre-1972	50	0.70
1972-74	90	0.67
1975-79	125	0.71
1980-89	175	0.66

Table 8-7 shows the correction efficiencies that were originally used in earlier versions of EMFAC2000. The correction efficiencies for option 3 represent those from an enhanced ASM testing program with a $450 repair cost limit.

Table 8-7 Correction Efficiencies Used in one version of EMFAC2000

	Model Year Group	Cost Limit ($)	1984 Level	1990 Level	Enhanced Training
Option 1 1984 I&M	Pre-1972	50	0.69	0.69	0.76
	1972-74	50	0.69	0.69	0.77
	1975-79	50	0.64	0.64	0.70
	1980-89	50	0.46	0.51	0.61
	1990+	50	0.46	0.51	0.61
Option 2 1990 I&M	Pre-1972	50	0.69	0.69	0.76
	1972-74	90	0.70	0.70	0.78
	1975-79	125	0.71	0.71	0.77
	1980-89	175	0.59	0.66	0.80
	1990+	300	0.64	0.72	0.82
Option 3 1998 I&M	Pre-1972	450	0.77	0.77	0.85
	1972-74	450	0.76	0.76	0.85
	1975-79	450	0.78	0.78	0.85
	1980-89	450	0.66	0.73	0.87
	1990+	450	0.66	0.74	0.87
Option 4	Pre-1972	No Limit	0.78	0.78	1.00
	1972-74	No Limit	0.78	0.78	1.00
	1975-79	No Limit	0.80	0.80	1.00
	1980-89	No Limit	0.70	0.78	1.00
	1990+	No Limit	0.70	0.78	1.00

Even after improving the accuracy of the repair correction efficiencies, the early versions of EMFAC2000 were predicting higher emission benefits than observed in the I&M evaluation programs. One of the main reasons behind the higher emission benefits was how the repair correction efficiencies were applied to the post-repair move matrix. The post-repair move matrix is based on near perfect repairs performed by CARB mechanics with unlimited resources. This represents the maximum movement (or perfect repairs) of vehicles with no limits on the repair costs. This movement is mitigated by the repair correction efficiencies. However, the movement of vehicles is still predicated on perfect repairs, which is fundamentally wrong. For example, with unlimited resources the mechanics are able to repair two super emitters to moderate and normal emission regimes. If the same mechanics were constrained by a $50 repair cost limit it is unlikely that these vehicles will be moved to the lower emission regimes. However, the methodology of using repair correction efficiencies to mitigate the movement of vehicles assumes that some fraction of these two vehicles would still be moved to the lower emission regimes. Given this, it was decided to base repairs directly on data collected during various I&M evaluation programs.

In the 1984 I&M evaluation program, should fail vehicles were given a baseline FTP test and a BAR 84 test at CARB's HSL facility. These vehicles were then sent for a smog check, including repair, to randomly selected stations in the SCAB. Upon their return, these vehicles were given an after-repair FTP test and a BAR 84 test. This data was used in calculating the repair move matrices used in EMFAC2000. Table 8-8 shows the repair move matrices for vehicles subject to the 1984 I&M program. Tables 8-9 and 8-10 shows the repair move matrices for vehicles subject to the 1990 I&M and enhanced I&M programs, respectively.

Table 8-8 Repair Move Matrices For Vehicles Subject to the 1984 I&M Program

		HC	HC	HC	HC	HC		CO	CO	CO	CO	CO		NOx	NOx	NOx	NOx	NOx
<1975	Baseline	Norm	Modr	High	Vhigh	Supr	Baseline	Norm	Modr	High	Vhigh	Supr	Baseline	Norm	Modr	High	Vhigh	Supr
Norm	73	0.8356	0.1644	0.0000	0.0000	0.0000	74	0.8919	0.0811	0.0270	0.0000	0.0000	101	0.8911	0.1089	0.0000	0.0000	0.0000
Modr	79	0.2785	0.6962	0.0253	0.0000	0.0000	69	0.3188	0.6087	0.0580	0.0145	0.0000	48	0.3333	0.5417	0.1042	0.0208	0.0000
High	17	0.2353	0.4706	0.2941	0.0000	0.0000	32	0.0313	0.6875	0.2188	0.0625	0.0000	27	0.1111	0.3333	0.5556	0.0000	0.0000
Vhigh	6	0.3333	0.5000	0.0000	0.0000	0.1667	9	0.0000	0.1111	0.3333	0.5556	0.0000	9	0.2222	0.1111	0.3333	0.2222	0.1111
Supr	11	0.0909	0.2727	0.2727	0.0000	0.3636	2	0.0000	0.0000	0.0000	0.5000	0.5000	1*	0.0000	0.0000	1.0000	0.0000	0.0000
	186						186						186					
MY Group		HC	HC	HC	HC	HC		CO	CO	CO	CO	CO		NOx	NOx	NOx	NOx	NOx
1975-79	Baseline	Norm	Modr	High	Vhigh	Supr	Baseline	Norm	Modr	High	Vhigh	Supr	Baseline	Norm	Modr	High	Vhigh	Supr
Norm	18	0.7222	0.2778	0.0000	0.0000	0.0000	57	0.7719	0.1930	0.0175	0.0175	0.0000	82	0.8415	0.1220	0.0366	0.0000	0.0000
Modr	70	0.1000	0.7143	0.1857	0.0000	0.0000	91	0.1319	0.7143	0.1209	0.0220	0.0110	80	0.2750	0.5625	0.1500	0.0125	0.0000
High	139	0.0072	0.1727	0.7914	0.0288	0.0000	69	0.0435	0.2029	0.6377	0.1159	0.0000	92	0.0978	0.0978	0.7609	0.0435	0.0000
Vhigh	37	0.0000	0.0270	0.4054	0.4595	0.1081	34	0.0588	0.2353	0.3235	0.3529	0.0294	23	0.0870	0.1304	0.3913	0.3913	0.0000
Supr	18	0.0000	0.0556	0.2778	0.2778	0.3889	31	0.0000	0.0645	0.1935	0.2581	0.4839	5*	0.0000	0.0000	0.0000	0.2000	0.8000
	282						282						282					
		HC	HC	HC	HC	HC		CO	CO	CO	CO	CO		NOx	NOx	NOx	NOx	NOx
1980-85	Baseline	Norm	Modr	High	Vhigh	Supr	Baseline	Norm	Modr	High	Vhigh	Supr	Baseline	Norm	Modr	High	Vhigh	Supr
Norm	55	0.7091	0.2727	0.0182	0.0000	0.0000	92	0.8587	0.1304	0.0109	0.0000	0.0000	115	0.8435	0.1391	0.0174	0.0000	0.0000
Modr	119	0.0840	0.8319	0.0840	0.0000	0.0000	100	0.2100	0.7000	0.0900	0.0000	0.0000	108	0.1667	0.7315	0.0926	0.0000	0.0093
High	76	0.0526	0.1711	0.7500	0.0263	0.0000	63	0.0794	0.2381	0.6667	0.0000	0.0159	38	0.0526	0.1842	0.6316	0.1053	0.0263
Vhigh	25	0.0000	0.2400	0.2800	0.4800	0.0000	12	0.0833	0.1667	0.4167	0.3333	0.0000	18	0.1111	0.0556	0.1667	0.5000	0.1667
Supr	11	0.0000	0.0909	0.3636	0.0909	0.4545	19	0.1579	0.1053	0.1579	0.0526	0.5263	7*	0.0000	0.1429	0.1429	0.1429	0.5714
	286						286						13	*0.0000*	*0.0770*	*0.1540*	*0.1540*	*0.6150*
		HC	HC	HC	HC	HC		CO	CO	CO	CO	CO		NOx	NOx	NOx	NOx	NOx
1986+	Baseline	Norm	Modr	High	Vhigh	Supr	Baseline	Norm	Modr	High	Vhigh	Supr	Baseline	Norm	Modr	High	Vhigh	Supr
Norm	55	0.7091	0.2727	0.0182	0.0000	0.0000	92	0.8587	0.1304	0.0109	0.0000	0.0000	115	0.8435	0.1391	0.0174	0.0000	0.0000
Modr	119	0.0840	0.8319	0.0840	0.0000	0.0000	100	0.2100	0.7000	0.0900	0.0000	0.0000	108	0.1667	0.7315	0.0926	0.0000	0.0093
High	76	0.0526	0.1711	0.7500	0.0263	0.0000	63	0.0794	0.2381	0.6667	0.0000	0.0159	38	0.0526	0.1842	0.6316	0.1053	0.0263
Vhigh	25	0.0000	0.2400	0.2800	0.4800	0.0000	12	0.0833	0.1667	0.4167	0.3333	0.0000	18	0.1111	0.0556	0.1667	0.5000	0.1667
Supr	11	0.0000	0.0909	0.3636	0.0909	0.4545	19	0.1579	0.1053	0.1579	0.0526	0.5263	7	0.0000	0.1429	0.1429	0.1429	0.5714
	286						286						286					

The arrows indicate substitutions for elements with insufficient data.

Table 8-9 Repair Move Matrices For Vehicles Subject to the 1990 I&M Program

		HC	HC	HC	HC	HC		CO	CO	CO	CO	CO		NOx	NOx	NOx	NOx	NOx
<1975	Baseline	Norm	Modr	High	Vhigh	Supr	Baseline	Norm	Modr	High	Vhigh	Supr	Baseline	Norm	Modr	High	Vhigh	Supr
Norm	63	0.8571	0.1270	0.0000	0.0000	0.0159	70	0.7429	0.2429	0.0143	0.0000	0.0000	115	0.9652	0.0348	0.0000	0.0000	0.0000
Modr	66	0.4394	0.5000	0.0606	0.0000	0.0000	73	0.3151	0.6301	0.0548	0.0000	0.0000	46	0.4130	0.4783	0.0870	0.0217	0.0000
High	21	0.0476	0.4286	0.4762	0.0476	0.0000	21	0.0000	0.4762	0.5238	0.0000	0.0000	8	0.2500	0.5000	0.1250	0.0000	0.1250
Vhigh	15	0.3333	0.2667	0.1333	0.0667	0.2000	12	0.0833	0.0833	0.3333	0.4167	0.0833	3	0.3333	0.0000	0.3333	0.0000	0.3333
Supr	11	0.3636	0.0909	0.0909	0.1818	0.2727	0	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	4	0.0000	0.2500	0.0000	0.5000	0.2500
176	176						176						176					
		HC	HC	HC	HC	HC		CO	CO	CO	CO	CO		NOx	NOx	NOx	NOx	NOx
1975-79	Baseline	Norm	Modr	High	Vhigh	Supr	Baseline	Norm	Modr	High	Vhigh	Supr	Baseline	Norm	Modr	High	Vhigh	Supr
Norm	6	0.5000	0.5000	0.0000	0.0000	0.0000	41	0.6829	0.2927	0.0244	0.0000	0.0000	79	0.8228	0.1392	0.0380	0.0000	0.0000
Modr	32	0.0313	0.5625	0.3438	0.0625	0.0000	87	0.1034	0.7126	0.1379	0.0345	0.0115	77	0.2468	0.5844	0.1558	0.0000	0.0130
High	145	0.0207	0.0897	0.8000	0.0897	0.0000	63	0.0794	0.2857	0.5397	0.0635	0.0317	86	0.2907	0.2326	0.4419	0.0349	0.0000
Vhigh	58	0.0345	0.0000	0.3276	0.5690	0.0690	50	0.0200	0.1400	0.3600	0.3600	0.1200	25	0.3600	0.0800	0.4000	0.1600	0.0000
Supr	40	0.0000	0.0000	0.3000	0.2000	0.5000	40	0.0000	0.0750	0.1000	0.2750	0.5500	14	0.0714	0.2857	0.0714	0.2857	0.2857
281	281						281						281					
		HC	HC	HC	HC	HC		CO	CO	CO	CO	CO		NOx	NOx	NOx	NOx	NOx
1980-85	Baseline	Norm	Modr	High	Vhigh	Supr	Baseline	Norm	Modr	High	Vhigh	Supr	Baseline	Norm	Modr	High	Vhigh	Supr
Norm	21	0.7143	0.2857	0.0000	0.0000	0.0000	57	0.7719	0.2105	0.0175	0.0000	0.0000	70	0.7571	0.2000	0.0429	0.0000	0.0000
Modr	84	0.0833	0.8095	0.1071	0.0000	0.0000	96	0.1771	0.6563	0.1667	0.0000	0.0000	127	0.1811	0.7087	0.0945	0.0079	0.0079
High	154	0.0390	0.0909	0.7468	0.1169	0.0065	160	0.0313	0.1500	0.7375	0.0750	0.0063	88	0.1023	0.3977	0.3636	0.1136	0.0227
Vhigh	118	0.0085	0.0678	0.2627	0.6186	0.0424	50	0.1000	0.0200	0.3000	0.4000	0.1800	76	0.0395	0.1711	0.2237	0.5263	0.0395
Supr	37	0.0000	0.0000	0.1892	0.4054	0.4054	51	0.0784	0.0784	0.2745	0.1765	0.3922	53	0.0377	0.1887	0.1132	0.2642	0.3962
414	414						414						414					
		HC	HC	HC	HC	HC		CO	CO	CO	CO	CO		NOx	NOx	NOx	NOx	NOx
1986+	Baseline	Norm	Modr	High	Vhigh	Supr	Baseline	Norm	Modr	High	Vhigh	Supr	Baseline	Norm	Modr	High	Vhigh	Supr
Norm	9	0.7778	0.2222	0.0000	0.0000	0.0000	21	0.8571	0.0952	0.0476	0.0000	0.0000	33	0.8182	0.1818	0.0000	0.0000	0.0000
Modr	29	0.1034	0.7586	0.1379	0.0000	0.0000	28	0.3571	0.4643	0.1786	0.0000	0.0000	27	0.2222	0.7407	0.0370	0.0000	0.0000
High	33	0.0303	0.2121	0.6667	0.0909	0.0000	24	0.0417	0.1667	0.6667	0.0833	0.0417	13	0.0000	0.3846	0.6154	0.0000	0.0000
Vhigh	12	0.1667	0.0000	0.1667	0.4167	0.2500	4	0.0000	0.0000	0.0000	0.2500	0.7500	7	0.0000	0.4286	0.2857	0.2857	0.0000
Supr	2	0.0000	0.0000	0.0000	0.0000	1.0000	8	0.0000	0.1250	0.1250	0.0000	0.7500	5	0.0000	0.0000	0.2000	0.2000	0.6000

The arrows indicate substitutions for elements with insufficient data.

Table 8-10 Repair Move Matrices For Vehicles Subject to the Enhanced I&M Program

Pre-1974

HC	Phase_1b	HC Norm	HC Modr	HC High	HC V_High	HC Supr	CO Phase_1b	CO Norm	CO Modr	CO High	CO V_High	CO Supr	NOx Phase_1b	NOx Norm	NOx Modr	NOx High	NOx V_High	NOx Supr
Norm	14	0.857	0.143	0.000	0.000	0.000	16	0.938	0.063	0.000	0.000	0.000	21	0.952	0.048	0.000	0.000	0.000
Modr	9	0.556	0.444	0.000	0.000	0.000	9	0.444	0.556	0.000	0.000	0.000	5	1.000	0.000	0.000	0.000	0.000
High	5	0.400	0.200	0.400	0.000	0.000	4	0.000	0.500	0.500	0.000	0.000	3	0.000	0.333	0.333	0.333	0.000
V_High	1	0.000	0.000	0.000	1.000	0.000	1	0.000	0.000	0.000	1.000	0.000	2	1.000	0.000	0.000	0.000	0.000
Supr	2	0.000	1.000	0.000	0.000	0.000	1	0.000	0.000	0.000	0.000	1.000	0	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Total	31						31						31					

1975-79

HC	Phase_1b	HC Norm	HC Modr	HC High	HC V_High	HC Supr	CO Phase_1b	CO Norm	CO Modr	CO High	CO V_High	CO Supr	NOx Phase_1b	NOx Norm	NOx Modr	NOx High	NOx V_High	NOx Supr
Norm	2	0.000	1.000	0.000	0.000	0.000	6	0.500	0.500	0.000	0.000	0.000	25	0.960	0.040	0.000	0.000	0.000
Modr	6	0.500	0.167	0.333	0.000	0.000	21	0.333	0.524	0.143	0.000	0.000	16	0.750	0.250	0.000	0.000	0.000
High	37	0.189	0.108	0.676	0.027	0.000	13	0.231	0.231	0.385	0.154	0.000	15	0.333	0.600	0.000	0.000	0.067
V_High	14	0.071	0.286	0.429	0.143	0.071	15	0.267	0.400	0.200	0.067	0.067	4	0.750	0.000	0.000	0.000	0.250
Supr	8	0.000	0.125	0.250	0.500	0.125	12	0.083	0.250	0.333	0.083	0.250	7	0.429	0.429	0.000	0.000	0.143
Total	67						67						67					

1980+

HC	Phase_1b	HC Norm	HC Modr	HC High	HC V_High	HC Supr	CO Phase_1b	CO Norm	CO Modr	CO High	CO V_High	CO Supr	NOx Phase_1b	NOx Norm	NOx Modr	NOx High	NOx V_High	NOx Supr
Norm	27	0.741	0.259	0.000	0.000	0.000	49	0.816	0.143	0.020	0.020	0.000	49	0.673	0.286	0.041	0.000	0.000
Modr	72	0.264	0.639	0.097	0.000	0.000	63	0.429	0.492	0.079	0.000	0.000	64	0.469	0.516	0.016	0.000	0.000
High	76	0.171	0.342	0.434	0.053	0.000	71	0.254	0.380	0.324	0.014	0.028	50	0.340	0.460	0.180	0.020	0.000
V_High	40	0.200	0.350	0.300	0.150	0.000	18	0.333	0.167	0.389	0.056	0.056	36	0.250	0.583	0.083	0.083	0.000
Supr	10	0.100	0.400	0.100	0.200	0.200	24	0.250	0.417	0.125	0.042	0.167	26	0.269	0.385	0.077	0.038	0.231
Total	225						225						225					

All Vehicles

HC	Phase_1b	HC Norm	HC Modr	HC High	HC V_High	HC Supr	CO Phase_1b	CO Norm	CO Modr	CO High	CO V_High	CO Supr	NOx Phase_1b	NOx Norm	NOx Modr	NOx High	NOx V_High	NOx Supr
Norm	43	0.744	0.256	0.000	0.000	0.000	71	0.817	0.155	0.014	0.014	0.000	95	0.811	0.168	0.021	0.000	0.000
Modr	87	0.310	0.586	0.103	0.000	0.000	93	0.409	0.505	0.086	0.000	0.000	85	0.553	0.435	0.012	0.000	0.000
High	118	0.186	0.263	0.508	0.042	0.000	88	0.239	0.364	0.341	0.034	0.023	68	0.324	0.485	0.147	0.029	0.015
V_High	55	0.164	0.327	0.327	0.164	0.018	34	0.294	0.265	0.294	0.088	0.059	42	0.333	0.500	0.071	0.071	0.024
Supr	20	0.050	0.350	0.150	0.300	0.150	37	0.189	0.351	0.189	0.054	0.216	33	0.303	0.394	0.061	0.030	0.212
Total	323						323						323					

The arrows indicate substitutions for elements with insufficient data.

8.6 Deterioration Rates

One of the major assumptions in the CALIMFAC model was that after vehicles have been redistributed among the emission regimes, they deteriorate at the same rate as other vehicles in that emission regime. This implies that vehicles in a particular emission regime have a deterioration rate that on a mileage basis is same with or without I&M.

In modeling the benefits from a vehicle scrappage program, staff noted that the emission benefits from the 1990 I&M program in calendar year 2010 were higher than indicated by data. They compared deterioration rates predicted by the model for an average 1987 model year vehicle to the deterioration rates from "should fail" vehicles in the 1990 I&M evaluation program and observed that the after-repair deterioration rates from the should fail vehicles were different than the without I&M deterioration rates. This implied a need for a separate set of deterioration rates for vehicles subject to an I&M program. In order to test the hypothesis that vehicle deterioration rates are the same regardless of whether or not they are subject to an I&M program, staff compared deterioration rates for vehicles subject to the 1984 (phase_2b) and 1990 programs (phase_2b) to vehicles not subject to an I&M program. In addition, staff wanted to ascertain if vehicles subject to the same I&M program deteriorate at the same rate when examined two years later. This involved comparing the deterioration rates for vehicles in phase_2b to phase_4b of the 1984 I&M program. In summary, this analysis indicated that vehicles that are not subject to an I&M program have deterioration rates that are different from vehicles subject to either the 1984 or 1990 I&M programs. Further, this analysis indicated that vehicles subject to the 1984 and 1990 I&M programs have similar deterioration rates.

Two methodologies were used to model the deterioration between inspection cycles. The first method involved determining the move matrices between inspection cycles for vehicles tested during the 1984 and 1990 I&M evaluation programs. These move matrices were then applied to the post-repair move matrix to redistribute the vehicles among the regimes thereby simulating deterioration over the two-year inspection cycle. The second method involved determining the vehicle's after-repair emissions and determining the age when the vehicle's emissions were first at this rate. This age is then used to calculate the migration rate, which on a regime basis is the difference between the regime sizes at (age+1)-(age). This difference in regime sizes is the deterioration rate for the next year.

The first method was modeled in an earlier version of EMFAC2000. This was done by calculating the movement of vehicles from Phase_1a to Phase_3b for vehicles tested in the 1984 and 1990 I&M evaluation programs. In the absence of data, staff assumed that vehicles subject to the enhanced I&M program will deteriorate at the same rate as vehicles subject to the 1990 I&M program. This method was eventually dropped because it predicted very high emission benefits for the 1990 I&M program; more than indicated by a previous study[2]. In addition the model predicted higher emission rates for vehicles

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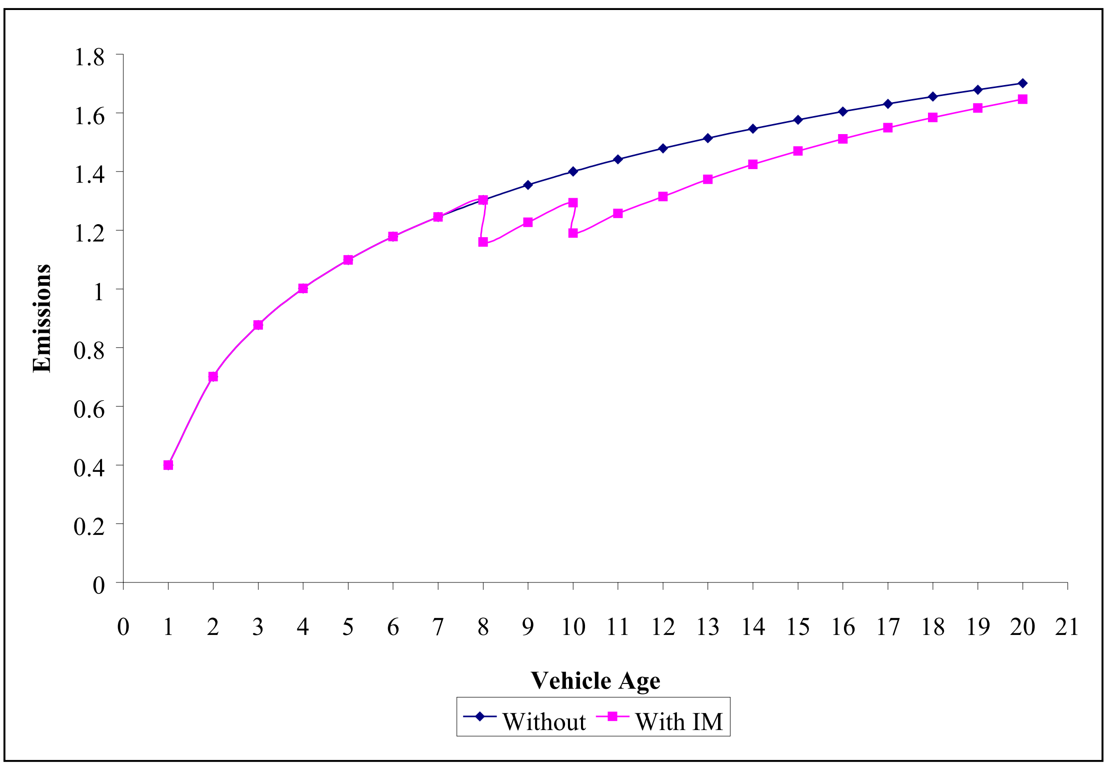
[2] Evaluation of the California Smog Check Program and Recommendations for Program Improvements, Fourth Report to the Legislature, February, 1993, by Sierra Research

subject to an I&M program than those not subject to an I&M program. These two results were contradictory, and were a direct result of the data used in calculating the move matrices. The move matrices indicated a very high deterioration rate with more super emitters being created after two years of deterioration. This resulted in I&M emission rates that in some instances were higher than the without I&M emission rates. However, at the next inspection the super emitters were promptly identified and repaired; hence the high emission benefits. In the I&M evaluation data only 34% and 35% of the vehicles were tested in subsequent phases of the 1984 and 1990 I&M evaluation programs, respectively. Staff believes that basing the deterioration move matrices on this subset of vehicles introduced a bias towards more malperforming vehicles.

Figure 8-5 conceptualizes how the second method calculates the with I&M emission rates. In this example, the vehicle undergoes its first inspection at age 8. This reduces the after-repair emissions as indicated by the step reduction in the emissions rate. The model then determines the age (age=6) when the vehicle first displayed this after-repair emission rate. The model then uses the deterioration rate from ages 6-7 as the next deterioration rate. What this figure illustrates is that the with this methodology, the with and without I&M deterioration rates are not the same.

Figure 8-5 <u>Example of how the With I&M Deterioration Rates are Calculated</u>



The second method was used in calculating the with I&M deterioration rates. This method was selected because it allows for the fact that with I&M deterioration rates can be higher than the without I&M rates.

8.7 <u>Discussion</u>

Currently, the CALIMFAC model uses move matrices that describe the maximum movement of vehicles from baseline to after-perfect-repair. This movement of vehicles is then mitigated via correction efficiencies (Table 8-5) to simulate I&M repairs. The correction efficiencies are a function of the I&M program repair cost limit and the level of mechanic repair effectiveness. Once the vehicles have migrated to (mainly) the lower emission regimes it is assumed that these vehicles deteriorate at the same rate as other vehicles in the emissions regime that they now occupy. Instead of using the correction efficiencies to calculate the repair move matrices, staff recommends using the repair move matrices in Tables 8-8, 8-9 and 8-10 to model repairs performed during the 1984, 1990 and 1998 I&M programs, respectively. The mechanic repair correction efficiencies should be set to 1.0. This means that the user will no longer have the option of doing "what if" analyses on the 1984, 1990 and enhanced programs. For example, in CALIMFAC the users could estimate the improvements in emission benefits in the 1984 I&M program as a result of enhanced mechanic training. This improvement was modeled via the repair correction efficiencies.

The CALIMFAC model assumed that vehicles, on an age basis, undergoing I&M program have the same deterioration rates as those vehicles avoiding an I&M. In EMFAC2000 the deterioration rate should be based on the after-repair emissions, and subsequent deterioration should be based on the vehicle's historical deterioration rates.